

PASSIVE SOLAR SUBDIVISION DESIGN:  
ITS IMPACT ON AIR QUALITY  
INCLUDING A LEGAL ANALYSIS OF  
SOLAR ACCESS LAW IN CONNECTICUT

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Abstract: This report evaluates the value of Public Act 81-334, An Act Concerning Passive Solar Design for Subdivisions as a tool for improving air quality in Connecticut. The report identifies the expected energy savings and emission reductions that may be achieved if local planning commissions adopt "solar conscious" standards for building orientations. It also identifies the opportunities and limitations of passive solar subdivision design as an economic development tool in a Region faced with the limitations of the offset provisions of the Clean Air Act. Finally, the report identifies current legal mechanisms for protecting access to sunlight that must be considered if energy savings or emission reductions are to be guaranteed.

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## Overview

This report addresses the potential role that passive solar subdivision design can play as a tool for reducing air pollution in Connecticut. It focuses upon the energy and emission reductions that may be achievable within the Central Naugatuck Valley Region under the mandate of Public Act 81-334, An Act Concerning Passive Solar Design for Subdivisions. The primary reason for undertaking this analysis has been to determine whether passive solar subdivision design might become an important local or state tool for bringing the Central Naugatuck Valley Region into attainment for the National Ambient Air Quality Standards for total suspended particulates (TSP). According to the National Clean Air Act any area which is in violation of the national ambient air quality standards for total suspended particulates is subject to certain economic development sanctions including a permanent halt to the construction of certain types of facilities that emit over 100 tons of total suspended particulates per year after all air pollution control equipment is installed. In order to avoid these possible economic development sanctions, the Central Naugatuck Valley Regional Planning Agency has explored cost effective techniques for bringing the Region into attainment for TSP. Rather than impose greater controls upon local industry, it was determined that substantial reductions in air pollution could be achieved by generators of air pollution that have hitherto been overlooked - namely single family homes.

According to the Clean Air Act any area that has not attained the national ambient air quality standards for TSP is subject to the requirement that any major facility emitting over 100 tons (after the installation of pollution control equipment) must offset its emissions by placing greater controls on existing industry in the Region or by finding alternative techniques that will ensure that there is a net air quality benefit achieved by the location of the firm within the non attainment region. Rather, than penalize new industries that might seek to locate in the Region by forcing them to find ways of offsetting their planned emission levels, it was the purpose of this demonstration program to identify ways that the City of Waterbury or the Central Naugatuck Valley Region could create an offset for use by any firms that might be subject to the offset provisions of the Clean Air Act.

The success of Public Act 81-334 as a tool for reducing emissions of TSP will in part depend upon the continuous availability of sunlight. While passive solar energy systems are non polluting they will only be able to supply a substantial amount of energy for space heating when solar access to the collector is protected and guaranteed. The second part of this report explores the legal mechanisms available to builders, homeowners and planning commissions considering legal mechanisms for guaranteeing the continuous usability of passive solar energy systems.



It emphasizes that solar easements and covenants are currently the only means of guaranteeing access to sunlight but that as local zoning and subdivision regulations are amended to meet the mandate of Public Act 81-334 it may be possible to protect solar access to one degree or another through municipal land use controls. These legal controls will be necessary not only to guarantee energy savings from passive solar design concepts but in order to assure that a real reduction in total suspended particulates levels has been achieved.



## Introduction

The Clean Air Act placed a great deal of emphasis upon reducing air pollution from industrial point sources. This philosophy has proved to be of limited value in areas like the Central Naugatuck Valley where industry has done about as much as it will ever be able to do to reduce its emission levels. Largely because of the limited opportunities of reducing emissions of total suspended particulates and sulphur oxides from industry, the CNVRPA has investigated the feasibility of reducing these emissions from smaller unregulated sources that contribute a great deal to the problem of air pollution but are not subject to government regulations.

In particular our efforts have focused upon the potential air pollution reductions that might be generated by reducing the energy consumed for residential space heating. There are many ways that the amount of energy used for space heating could be reduced. For example, energy conservation measures could be applied to existing dwelling units or building performance standards for energy efficiency, could be developed for new dwelling units. However, these approaches were discarded since the first approach cannot be easily implemented or documented and the second approach is entirely within the domain of the State building code. Consequently, the CNVRPA chose to evaluate the energy and air quality benefits that could be developed by local governments because any air quality benefits developed at this level of government could also be controlled at this level of government as well. In particular, our efforts have focused upon the potential air pollution reductions that might be generated by local zoning and subdivision regulations mandating energy conservation and the application of passive solar design concepts in subdivisions. Since 1978 the CNVRPA has assisted four municipalities in the Central Naugatuck Valley Region with the adoption of solar access and passive solar design regulations within local zoning and subdivision ordinances. Middlebury (October 1980), Naugatuck (May 1981), Southbury (June 1981) and Wolcott (June 1981) have adopted provisions within their zoning and subdivision regulations that (1) require the proper orientation of streets, lots and buildings and (2) protect access to sunlight for solar collectors installed within new developments. These provisions assure that dwelling units built in the future will take advantage of solar energy to one degree or another to meet their space heating needs.

Partly as a result of lobbying efforts undertaken by the CNVRPA staff, the Connecticut State Legislature has recently passed Public Act 81-334 (An Act Concerning Passive Solar Design for Subdivisions) that mandates all planning commissions to develop regulations so that developers consider passive solar energy in the design and layout of streets, lots, and buildings in all proposed subdivisions received after October 1, 1981. Public Act 81-334 could have a substantial impact on the space heating demand of dwelling units built after October 1, 1981.



In order to determine the likely energy savings and emission reductions attributable to proposed and adopted solar access regulations in the Central Naugatuck Valley Region, three alternative scenarios were developed for residential developments built between 1981 to 1990. The three scenarios compare varying levels of expected acceptance of passive solar subdivision design concepts to the no change scenario in order to determine the likely annual energy savings and emission reductions that might be attributed to adopted subdivision amendments mandating passive solar energy techniques.

### No Change Scenario

The no change scenario assumes that houses constructed over the period 1981 to 1990 will be oriented in a random fashion. This assumption was based on the fact that a previous study done by the CNVRPA revealed that past building practices largely ignored considerations of solar conscious house orientations or passive solar design concepts. Table 2 indicates that the no change scenario projects that 11,700 new dwelling units will be constructed by 1990 and that an equal number of units (2,800) will have their long axis facing true south, 30 degrees off true south, 45 degrees off true south and 90 degrees off true south. The no change scenario also assumes that a very small number of suntempered and passive solar dwelling units would be built even without the legislative mandate of Public Act 81-334.

### Passive Solar Development Scenarios

In contrast to the no change scenario, it is expected that local amendments to subdivision regulations stimulated by Public Act 81-334 will lead to three possible levels of energy savings attributable to house orientation. The minimum level of acceptance of Public Act 81-334 assumes that new dwelling units will face south to a far greater degree than would have occurred if the no change scenarios came about. However, it is possible that Public Act 81-334 may also stimulate the market for passive solar dwelling units leading to greater utilization of passive solar design concepts than would be created by local subdivision regulations on their own. These two market scenarios are the increased south glass scenario and the passive solar scenario. Neither of these two scenarios can be considered a direct benefit derived from the adoption of passive solar subdivision design concepts since local subdivision regulations have no control over the amount of thermal storage capacity within the dwelling unit. Whatever energy and air quality benefits that are created above and beyond the mandate of Public Act 81-334 will simply be unanticipated benefits derived from passive solar subdivision design.



### Southern Orientation Scenario

Passive solar design concepts would create significant energy savings by a greater commitment to "solar conscious" orientations of new homes. The Southern Orientation Scenario assumes that 70% of all new homes built between 1981 and 1990 will face true south and that 20% of all homes will incorporate passive solar design considerations including increased south glass and thermal storage capacity. The southern orientation scenario reflects the ideal pattern of development that could emerge if all local planning commissions were to exercise a great deal of control over house orientation. It is probably unrealistic to expect 70% of all new homes to face true south but such a hypothesis serves to reveal the maximum value of Public Act 81-334 as a potential tool for reducing air pollution in the Central Naugatuck Valley Region.

### Increased South Glass Scenario

The increased south glass scenario assumes that only 50% of all new dwelling units will face south. However, it assumes that 60% of all new dwelling units will have an increased amount of south facing glass and that 10% of all new units will incorporate passive solar design considerations including south facing double glazed window walls and thermal storage capacity. (See Table 2). This scenario assumes that increased use of south facing glass or passive solar design concepts will emerge as an indirect benefit of passive subdivision design standards but not because such items are required by local regulations. Therefore, the offsets created under this scenario can not be credited to the adoption of passive solar subdivision design regulations. They merely indicate the potential air quality benefits that may be stimulated by Public Act 81-334.

### Passive Solar Scenario

The most dramatic energy savings that may be stimulated by solar subdivision design ordinances will emerge if a substantial portion of all new dwelling units incorporate passive solar design concepts including increased south facing, double glazed window walls and adequate thermal storage capacity. This highly optimistic scenario assumes that 50% of all new dwelling units constructed during the next ten years will include passive solar design concepts and 75% off all new units will face true south. (See Table 2).

While the air quality benefits derived from the increased production of passive solar dwellings can not be credited to the adoption of passive solar subdivision regulations by themselves, this scenario serves to illustrate the maximum air quality benefits achievable if almost all new houses utilized the sun for space heating to the greatest degree possible. Consequently, this scenario is primarily a reference point for evaluating less optimistic scenarios.



## Energy Impact of the Passive Solar Scenarios

The three alternative scenarios were developed based on a detailed study of the expected energy requirements of three likely dwelling types to be built over the next decade; (1) conventional dwellings, (2) suntempered dwellings and (3) passive solar dwellings oriented at varying degrees off true south.<sup>1</sup> Table 1 identifies the fossil fuel requirements of each dwelling type at varying orientations off true south. Table 2 identifies the expected development patterns associated with these three alternative scenarios. Table 3 quantifies the projected energy requirements of all new dwelling units under each scenario and Table 4 quantifies the projected annual energy savings (in gallons of fuel oil) that would be achieved by implementation of each of the three alternative scenarios.

Large energy savings are possible under each of the three passive solar scenarios. At one extreme if Public Act 81-334 inadvertently encourages the installation of increased south facing double glazed window walls in most new homes the increased south glass scenario could reduce fuel oil consumption by 167,755 gallons a year for the 11,700 new units built by 1990.<sup>2</sup> A policy requiring southern orientations for new dwelling units would offer substantial energy savings by 1990 amounting to a savings of 1,032,310 gallons of oil a year compared to the no change scenario. Finally, the highly optimistic passive solar scenario could reduce fuel oil consumption by 1,218,990 gallons of oil per year compared to the no change scenario. While each scenario results in energy savings, only the southern orientation scenario establishes the basis for an offset since it reflects the impact of implementing Public Act 81-334.

## Air Quality Impact of the Three Alternative Scenarios

The emission reductions achieved by the three alternative scenarios in large measure depends upon the fuels used to supplement the contribution made by solar energy to space heating.

The fuel mix for 1990 assumes that there will be a shift to dirtier fuels such as coal and wood (see Table 5).

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<sup>1</sup> See Appendix 1 for a description of the assumptions used in formulating the three building types.

<sup>2</sup> This analysis assumes that fuel oil is the only backup fuel used by all new homes. While this is not likely to occur it serves to indicate the energy impact in terms that are most easily understood to most Connecticut residents.



The underlying assumption of the fuel mix projection is that cheaper fuels will become more popular over the next decade with coal and wood being used in 30% of all new dwelling units and natural gas in 20% of all units. While there is no accurate source of information on the fuels currently used for space heating, it appears that many dwelling units are incorporating coal or woodstoves for primary or supplementary space heating. Nonetheless, fuel oil is expected to remain the principal means of home heating in 1990 (see Table 5).

In order to determine the air quality impact created by the projected 1990 fuel mix it is necessary to transform energy requirements expressed in British Thermal Units (BTUs) into energy requirements expressed in specific units of measurement (ie. gallons of oil or cubic feet of gas). Based on the BTU values of various fuel types (see Table 6), it is possible to determine the actual amount of each fuel type necessary to supply the projected 1990 space heating requirements for the 11,700 dwelling units built between 1981 and 1990 (see Table 7).

Annual emission reductions can now be calculated for the five pollutants for which the U.S. Environmental Protection Agency has established National Ambient Air Quality Standards. The projected emission reductions are based on emission factors for oil, gas, electricity, wood and coal since these are expected to be the most common fuels used for space heating (see Table 8). These emission factors were applied to the quantity of each fuel type expected to be saved by the implementation of the three alternative scenarios (see Table 9). The emission reductions generated by the fuel savings under each of the three alternative scenarios range from 14 tons of TSP under the Increased South Glass Scenario to 95 tons of TSP under the Passive Solar Scenario (see Table 10). Similarly, emission reductions for  $SO_x$  range from 15 tons (Increased South Glass Scenario) to 113 tons (Passive Solar Scenario).

#### Potential Offsets Generated by the Alternative Scenarios

Emission reductions for total suspended particulates are of primary concern in the Central Naugatuck Valley Region since the Region will remain non attainment for this pollutant until 1982. Theoretically, if any of the 22 industry groups regulated by the Clean Air Act expects to build a plant that would emit over 100 tons of TSP after air pollution controls are in place, the Clean Air Act would require them to offset emissions in the Region by an amount greater than that generated by the new plant before they could start construction.



This policy has been of concern to many economic development officials since it could slow the rate of economic development in the Region. A CNVRPA study, The Emission Offset Policy, clearly indicates that existing point sources of pollution will not be able to generate sufficient emission reductions to create an offset for any new industry contemplating a location in the Region. Consequently, area source reductions (such as from home heating) offer the only real offset tool to local or state officials seeking to bring the Region into attainment for total suspended particulates.

The most likely scenario for new residential development appears to be the Southern Orientation Scenario. Based on the assumptions made in this study, annual emission reductions of 80 tons of total suspended particulates may be possible by 1990 under this scenario. Table 10 indicates that these large emission reductions will emerge as a result of an increased utilization of dirty fuels such as coal and wood. If this projected fuel mix hypothesis is not correct emission reductions generated by the Southern Orientation Scenario would be dramatically reduced. For example, if all new dwelling units utilize fuel oil for space heating, the total emission reductions attributable to the Southern Orientation Scenario would only amount to about one ton of TSP. (See Table 11). This certainly would not be a significant offset nor would it contribute in any significant way to cleaner air.

However, for Sulphur Oxides, emission reductions attributable to the Southern Orientation Scenario appear to be fairly consistent between the 1990 fuel mix projection and an all fuel oil projection. A total of 96 tons of SO<sub>x</sub> would be eliminated under the 1990 fuel mix projection and 74 tons would be eliminated under an all fuel oil projection. Consequently, the Southern Orientation Scenario appears to offer rather reliable emission reductions for SO<sub>x</sub> whereas, it does not appear to offer reliable emission reductions for TSP.

In large part the economics of fuels used for space heating will strongly influence the potential emission reductions attributable to any of the three alternative scenarios. To assume that coal and wood will be used for space heating in 30% of the housing units built over the next decade appears quite reasonable in light of rapidly increasing costs of fuel oil and electricity. However, only time will tell the extent to which these traditional fuels (ie. wood and coal) will begin to substitute for electricity and fuel oil.

#### Documentation of Emission Reductions

Unlike emission reductions from a smokestack which can be measured, it is much more difficult to measure the emission reductions attributable to these three alternative scenarios for future residential development. While there will certainly be some level of emission reductions there are several problems faced in attempting to document the validity of these reductions.



Administrative Complexity: In order to be usable as offsets, any local government that wishes to take credit for emission reductions attributable to the southern orientation of buildings or the application of passive solar design concepts must quantify the number of new units that meet certain minimum energy efficiency criteria. Moreover, any attempt to create an offset from passive solar design concepts should be documented by heat loss and heat gain calculations so as to verify the expected emission reductions generated. These extensive mathematical calculations could be reduced to a degree by making certain standard assumptions as to (1) the heat loss per square foot of floor area for a variety of building types and (2) the percentage contribution made by solar energy to the annual space heating requirements through the use of south facing double glazed window walls in new buildings. Nonetheless, even with these simpler assumptions one still would need to know the number of new housing units, their orientation with respect to true south, their floor area and the square feet of south facing windows.

Permanence of the Reduction: Offsets used by a local government must be permanent and enforceable if they are to be usable as an economic development tool. The emission reductions generated by any of the three alternative scenarios might not always be the same, due to yearly variations in the percentage of sunshine, and in heating degree days. In effect, the amount of fuel used to supplement the contribution made by solar energy to space heating will depend upon the number of degree days in the heating season and the amount of time the sun is shining. Perhaps, the easiest means of addressing this problem is by assuming that emission reductions generated by the three alternative scenarios will be based upon long term averages for heating degree days and long term averages for the percentage of sunshine available in the Region. This approach recognizes that yearly variations in emission reductions are likely to exist but that over the long term these reductions will be relatively stable. However, one problem that is not so easily solved is fuel switching by homeowners. If homeowners unexpectedly make a rapid switch from coal and wood to natural gas as the primary home heating fuel the potential emission reductions attributable to the three alternative scenarios could vanish overnight.

Existence of the Reduction: Unlike pollution control equipment placed on a smokestack, the installation of passive solar design concepts into a dwelling does not appear to visibly reduce air pollution emissions. To prove that emissions have been reduced by solar energy requires a comparison to the emissions generated by the same dwelling unit without the aid of solar energy as a supplementary fuel source. However, since all conventional dwelling units having double glazed windows facing within 60° degrees of true south receive some level of space heating from the sun (see Table 12), the existence of these emission reductions depends upon an assumption on the orientations of dwelling units if there are no local subdivision ordinances requiring buildings to have a "solar conscious" orientation. A recent analysis of past building practices in four municipalities in the Region revealed that it is safe to assume that building orientation without "solar conscious" regulations would essentially be random.



Based on this assumption the easiest means of verifying the emission reductions attributable to the "solar conscious" regulations is to assume that without the regulation the same building would have had a net solar energy gain equivalent to a randomly oriented house. The difference between the solar energy gain between the randomly oriented house and the "solar conscious" oriented house would reflect the net energy benefit derived by the passive solar subdivision design amendments. Table 13 quantifies the energy savings generated by conventional, suntempered and passive solar house designs at various orientations to true south over a randomly oriented conventional house.

In order to calculate energy savings, one only needs to know the total number of new dwelling units that will be built as conventional, suntempered or passive solar design at the four orientations listed in Table 13.

For example, if all new dwelling units constructed between 1981 and 1990 were of conventional design and faced true south, by 1990 about 360,551 gallons of oil could be saved each year.

$$\left[ \frac{3.02 \text{ MBTU savings at true south} \times 11,700 \text{ new conventional dwellings}}{98,000 \text{ BTU/gallon of fuel oil}} = 360,551 \right]$$

However, as another example, if all new dwelling units in the Region were built as passive solar houses at an orientation of 30 degrees off true south, the fuel oil savings would be about 4,112,908 gallons a year.

$$\left[ \frac{33.45 \text{ MBTU savings at } 30^\circ \text{ off true south} \times 11,700 \text{ new passive solar dwellings}}{98,000 \text{ BTU/gallon of fuel oil}} = 4,112,908 \right]$$

Clearly these examples reveal that emission reductions can be generated by passive solar design concepts which could be used as part of an attainment strategy by the State Department of Environmental Protection or as an offset strategy by a local government. However, because it takes a large number of passive solar dwelling units to generate small quantities of emission reductions, it appears that the benefits of this emission reduction strategy will be more usable by State or Regional levels of government than by a local government. Moreover, only the Southern Orientation Scenario (which assumes conventional dwelling units will face true south to a greater degree than the No Change Scenario) can be considered to have sufficient legal support to be claimed as a government credited offset. The other two passive solar scenarios reflect market as well as regulatory forces and therefore can not be credited entirely to government sponsored regulations.



## Application of Offsets as an Economic Development Tool

According to a recent study on air pollution offset trading, most offset purchases involve substantial quantities of pollutants. As can be seen in Table 14, the average quantity of offsets required in past transactions involving total suspended particulates was 290 tons with a range from 3.5 to 1,162 tons. This indicates that the southern orientation scenario would probably only be able to generate one offset transaction if the planning region is accepted as a legitimate geographic area within which offset trading can occur. However, since Regional Planning Agencies would probably have no authority to engage in offset trading, the offsets generated by the southern orientation scenario would be better administered by the State Department of Economic Development if local governments would allow DED to take credit for their offsets. In one sense, the state can take credit for the adoption of passive solar subdivision regulations that reduce air pollution since the State mandated that such regulations be adopted. This approach would be the best from an administrative viewpoint since DED is the only governmental organization that could generate sufficient offsets to be useful to new or expanding industry.

Nonetheless, local governments such as Waterbury might be able to generate sufficient offsets to meet the requirements of a small transaction. Since Waterbury is expected to account for 21 percent of all new dwelling units built between 1981 and 1990, the City should also be able to take credit for 21 percent of the offsets projected to be created under the southern orientation scenario. Under the scenario associated with implementing Public Act 81-334, Waterbury could generate about 17 tons of TSP offsets by the year 1990. While that is not a substantial offset, the value of the offset generated by southern orientation scenarios is that it is inexpensive to create (it only requires houses to face south) and does not burden industry with additional costs for compliance with the Clean Air Act.

### Summary

Offsets can be created by reducing residential space heating requirements through the use of passive solar design concepts and house orientation, which could be used to meet the offset needs of future industry in the Waterbury area. Offsets created by the southern orientation scenario suggested in this study could be documented and would be a permanent reduction in the level of particulate matter in the air if fuel switching is not prevalent. Even greater emission reductions are possible if the market for passive solar homes is stimulated by the mandate of Public Act 81-334. But these additional emission reductions can not be credited to the impact of



passive solar subdivision regulations. Because of the large number of dwelling units that are required to produce the average offset of TSP, it appears that the State Department of Economic Development is the most likely organization to control the offsets created through the passive solar design scenarios. However, it is possible that a larger city like Waterbury might be able to generate a sufficiently large offset through the administration of its passive solar subdivision regulations to meet the offset trading needs of some industries in certain circumstances. The imposition of passive solar regulations should not increase the cost of housing since subdivision regulations will only be influencing the orientation of the house. In addition, most of the developable land in the Region requires minimum lot sizes of one or two acres. Zoning should not constrain building orientation to any great degree, although topography may constrain orientation in some cases. The southern orientation scenario does not assume that conventional dwelling units will cost more for windows or thermal storage capacity since no additional window area or storage capacity was added into the house. Energy savings and air quality benefits merely reflect the value of southern orientation for windows.



## Access Rights to Sunlight

The increasing recognition of the sun as a viable energy source and the newly passed Connecticut legislation concerning passive solar design for subdivisions, raise questions about continued access rights to sunlight. Without a guarantee of legal protection, the development of subdivisions with passive solar energy design may do nothing to encourage use of solar energy. Although a home is designed to make the optimum use of passive solar energy, once the source of sunlight has been eliminated or substantially diminished by land use on adjoining or neighboring properties, even the best passive solar design will become virtually worthless.

Legal attitudes in the United States have been premised on the use of highly concentrated forms of energy which are distributed to the consumer by man-made routing systems.<sup>1</sup> In contrast, solar energy is distributed naturally in the form of low grade heat which varies considerably with latitude, season, time of day, and weather conditions. Currently there is no set body of case law which provides a clear basis for the protection of solar rights. Several states have remedied this uncertainty by passing strong solar access legislation, but in the majority of states the individual home owner must still utilize traditional property law to protect needed solar access.

Solar access is not a new legal issue. Initially, access to sunlight concerned a legal right to sunlight for illumination purposes. The central issue is the right of a homeowner to sunlight which flows across neighboring properties.

At common law it was generally accepted that a person could build as he pleased on his property irrespective of his motive.<sup>2</sup> However, beginning in the late nineteenth century, this doctrine began to be diminished by the courts and legislatures. It was soon established that the use of one's property solely to injure another was not one of the immediate rights of ownership. A person would be denied the right to build upon his property if his motive was solely to harass his neighbor.<sup>3</sup> Being a property owner does not give an absolute right to use that property in any manner:

Property, like liberty, has been taught that some of its most cherished immunities are not absolute but relative. We shall have to learn as the years go by to distinguish more and more between what is essential in the concept of ownership and so invariable under the constitution and what is accidental or unessential, and so variable and severable at the call of social needs.



This section will explore the legal doctrines available to the individual owner for the continued legal protection of his access to sunlight. The new zoning and subdivision regulations, that are slowly being developed in Connecticut pursuant to the mandate of state law, may offer some protection. The amount of protection will depend largely on the careful drafting of the zoning and subdivision regulations and whether such zoning is combined with an updated building code.<sup>5</sup> Where "solar conscious" zoning or subdivision regulations have not been passed, each individual homeowner utilizing solar energy will have only the common law doctrines to use in the protection of his access to sunlight.

Presently, to assure adequate and continued access to sunlight, the following traditional property principles may be used: Express covenants, express easements, implied easements, prescriptive easements and an action in nuisance. Each will be discussed.

### Creation of Solar Access by Covenant

A covenant is an agreement of two or more parties to a deed in writing in which either of the parties pledges to the other that something is done or shall be done.<sup>6</sup> With regard to the access to sunlight, covenants may be imposed to create access to sunlight across adjoining properties. Two adjacent landowners may enter into a written agreement and, if properly drafted, such agreement will be binding on subsequent owners of the parcels of land and cannot be transferred separate from the land. If a large tract of land is involved, any subdivision of that land will not extinguish the covenant, but each property owner of the subdivided land will be bound by the original agreement or covenant.<sup>7</sup>

Courts have uniformly upheld express covenants which restrict obstruction of sunlight for illumination, free flow of air or a picturesque view. These cases remain good precedent for upholding and enforcing express creation of solar access easements.

In 1890, Justice Oliver Wendell Holmes, Justice of the Massachusetts Supreme Court, wrote, in his opinion in the case of Ladd v. City of Boston,<sup>8</sup> stated that easements of lights and air may be created across neighboring land within reasonable limits, by words of covenant as well as words of grant. In Ladd, the litigants' predecessors in title were parties to an indenture, whereby it was covenanted that the land in front of and immediately across the street from the plaintiff's property could not be built upon above a certain height. The city subsequently bought this property and proceeded to build upon the restricted zone. The plaintiff sued the city for taking his easements of light and air by constructing a courthouse higher than the prescribed limits. In 1878, in the case of Lattimer v. Levermore,<sup>9</sup> the court enforced a covenant which provided the plaintiff landowner an easement of air, light and vision. In Jackson v. Eli,<sup>10</sup> a 1904 case from Washington, D.C., the court upheld and construed a covenant created in 1860 which prohibited the grantor and his successor from obstructing windows of a house conveyed to the grantee (and his successors).



Recent cases have echoed these earlier court decisions. A 1978 Hawaiian case, Sandstrom v. Larsen,<sup>11</sup> the court upheld an order to demolish a house which was built in violation of a height restriction covenant to protect the view and where the builder had knowledge of the covenant and several warnings that the covenant was being violated.

In Day v. McEwen,<sup>12</sup> a 1978 Maine case, the court construed a covenant for unobstructed view and the burdens it placed upon the restricted party. The deeds involved were traced to a single owner who had placed a reservation of an ocean view on the plaintiff's parcel and a covenant not to obstruct that view on the defendant's parcel. The plaintiff sued defendant for planting and allowing trees and bushes to grow in such a manner as to obstruct the plaintiff's view of the ocean. The court held that the covenant of unrestricted view imposed a duty on the defendant not to permit the natural growth to obstruct the plaintiff's view. The Court stated that an unobstructed view of the ocean was regarded by all parties as contributing to the property's value. In addition, the parties accepted and knew about the ocean view covenant when they took the deed. The enforcement of the covenant in Day is similar to the enforcement necessary for a solar access easement. It is irrelevant whether the obstruction is manmade or natural: the open, unobstructed area must remain open and unobstructed. It is reasonably certain that a covenant creating an easement for solar access would also contribute to the value of the property. The passive solar design and/or an energy system powered by the sun would be a valuable addition to any home and its obstruction would diminish the pragmatic use and subsequently the value of the property.

The burden placed upon the restricted party by covenants concerning free access to illumination, air and view is the same that would be imposed on the restricted party by a covenant for solar access. The restricted party would be prohibited from blocking the flow of sunlight to his neighbor's home. Since Connecticut courts have uniformly enforced an unobstructed view covenants<sup>13</sup> it is expected that the court would enforce a solar access covenant.

#### Creation of Solar Access by Easement

An easement is a privilege which accrues to the owner of one tract (dominant tenement) from the land of another tract (servient tenement). The servient tenant is obliged to refrain from doing something on or in regard to his tract for the benefit or advantage of the dominant tenement.<sup>14</sup>



There are basically three ways of creating easements. The first is by a written agreement between two parties. This is an express easement. The second type of easement arises by implication. "Implied easements" are continuous, apparent and reasonably necessary for the enjoyment of the land and which pass by implication when that property is conveyed. The third type of easement is acquired by the long term enjoyment of the easement by the person claiming a right to use such easement. An "easement by prescription" ripens into a legal right after a number of years (15 in Connecticut) where one landowner knowingly acquiesces in another person's claim and enjoyment of an easement without interruption or molestation.

### Express Easement

An "express easement" is a written document which may be explicit language in a deed either conveying or reserving the easement with the person conveying the property.<sup>15</sup> The written document may be separate from the deed of conveyance. For example, a person may convey a portion of his land to another but reserves an easement of access to sunlight across the property conveyed. Conversely, the person conveying the property may grant the new owner the right to receive unobstructed sunlight across the original owner's property.

The courts have traditionally treated express easements the same as express covenants and will uphold these agreements between landowners and their successors in title where applicable. The right to light and air from adjoining premises can easily arise from a grant of an express easement. In this particular case, the easement is deemed to be "negative"; that is, the servient estate agrees to refrain from doing something. In the case of a express negative solar easement, the servient estate agrees not to obstruct the dominant estate's right to sunlight. The express negative easements for light and air can be conveyed by covenant or mutual agreement and such will define the burden the dominant tract imposes on the servient land.

### Implied Easements

An implied easement is created by a court. The theory applied by the court is that when an owner of a tract of land conveys a part thereof he also conveys, by implication, easements that are continuous, apparent and reasonably necessary for the enjoyment of the tract. The grant of an easement is based upon the supposed intention of the parties to a transaction as deduced from the surrounding facts and conditions of the land to which the easement relates and not upon any specific language in the deed.<sup>16</sup> Essentially, the court is asked to make the easement part of the conveyance where the parties fails to include the easement in any documents. If the court finds that the easement is visible, known to the parties and is necessary for the reasonable use of the dominant estate at the time of the conveyance, then such easement will arise by implication.<sup>17</sup>



Courts have analyzed the doctrine of implied easements as it is applied to sunlight rights<sup>18</sup> and are divided concerning its applicability. Some courts have absolutely refused to extend the doctrine to sunlight while other courts have sparingly applied the doctrine on a case by case analysis. Connecticut courts have adopted the latter view.

The line of Connecticut cases make it clear: Implied grants of easements of light and air not reasonably necessary for the enjoyment of rights expressly granted are not favored.<sup>19</sup> Connecticut courts have implied the existence of easements for sunlight only where strictly necessary; where there is merely diminished sunlight, the courts have found no necessity but rather, mere convenience.

Furthermore, Connecticut courts have refused to imply sunlight easements if substitute or alternative forms of illumination were available at a reasonable cost. The easement, also, must be so obvious and apparent to the servient tenant (the adjoining property owner) that he could be charged with knowledge that the courts would forbid him from using his land in a way that would obstruct the sunlight.

A compelling case could be made for applying an implied easement analysis where there is an obstruction to sunlight for an individual's solar energy collector making that system virtually worthless. However, the question is not clear where there is merely impairment to the proper functioning of a passive or active solar system.

A doctrine of implied easement has little applicability where, at the time of conveyance, the easement of access to solar energy is not visible, known to the parties and necessary for the reasonable use of the dominant estate. Subsequent changes to solar energy will not give rise to an implied solar access easement.

#### Prescriptive Creation of Solar Access Easements

In order for an easement by prescription to arise and ripen into a legal right, four factors must be established: (1) the use of the easement must be either with the knowledge of the person against whom the easement is claimed, or so open, notorious, visible and uninterrupted that the knowledge of the person against whom it is claimed will be presumed. (2) The use must be exercised under a claim of right adverse to the interests of the property owner. (3) The use must be acquiesced in by the owner. Acquiescence in this context means a passive submission to the user's conduct by the property owner, not consent or permissive use of the easement. (4) The use must be continuous and uninterrupted for a period of time. This period of time is controlled by state law and in Connecticut, the time required is 15 year.



The English doctrine of ancient lights, whereby an easement arises for the flow of light across adjacent property upon proof of continuous use for at least 20 years,<sup>20</sup> is the fundamental common law of easements arising by prescription. However, prescriptive creation of sunlight and air easements has been uniformly rejected by United States Courts since the early 20th century. Easements by prescription were judged not to be appropriate to the land development conditions existing in this country. The rejection of the "Ancient Lights Doctrine" was rooted in the popular perception of America as a frontier nation where the land was to be developed fully without restriction.<sup>21</sup>

Nevertheless, some prescriptive easement cases contain a suggestion that the doctrine might be applicable for solar access protection under certain conditions. The issue is whether a landowner acquires an easement by prescription for sunlight through the long term use of that sunlight.<sup>22</sup>

Under the doctrine of easements gained by prescription, the dominant tenant violates a right of the servient tenant during the prescriptive period. Because there is no violation in the case of solar access, the servient tenant has no legal action available to halt the use of a solar collector or of the passive solar design. The only recourse open to the servient tenant (the adjoining property owner) is to erect a barrier to obstruct the passage of sunlight across his property onto the dominant tenant's solar collector or home. Under the prescriptive easement doctrine, the servient tenant who fails to act could suddenly find the use of his property limited. There appears to be little difference whether the prescriptively-claimed sunlight easement is utilized by the dominant tenant for illumination or for effect on the servient tenant and that such effect remain unchanged for the requisite period. (ie., the dominant tenant is still utilizing sunlight passing over his neighbor's property).

Some courts have tried using a balancing test in ascertaining whether there is a prescriptive right to solar access. The balance hinges on whether there was a substantial deprivation of sunlight. That is:

The privation of light and air by a proposed erection will be in such a degree as to render the occupation of the complainant's house uncomfortable, if it be a dwelling house, or if it be a place of business, the privations must render the exercise of the business materially less beneficial than it had formerly been.<sup>23</sup>



If the court utilizes this balancing test, the need for encouraging use of solar power by individuals should be an important factor considered in this balancing process. On the one hand, there is the reliance interest of the solar energy user and on the other hand is the desire of the servient tenant to utilize and develop his property. However, before such a balancing approach can be utilized to any extent by the Connecticut courts, a re-evaluation of the prescriptive easement analysis would be necessary. The current approach requires an invasion of the servient tenant's rights, which can be remedied through legal action. The balancing approach emphasizes the benefits accruing to the dominant tenant (the user of solar energy) and the servient tenant's ability to halt the prescriptive creation through physical obstruction.

Courts, because of the increasing interest in solar energy, could adopt a flexible approach as they have in cases concerning the creation of prescriptive aviation easements. An aviation easement is an easement across the airspace above land through which airplanes have the right to travel. Where a prescriptive aviation easement is recognized by the court, the servient tenant is precluded from placing obstructions within the confines of the easement.<sup>24</sup> Solar access easements created by prescription could follow a similar flexible approach whereby the servient tenant could use his land as he pleased so long as a corridor was left free of obstruction to assure complete solar access to the dominant tenant.

Even if the courts adopt a balancing analysis and/or a flexible approach to solar access by prescription, there still remains the one obstacle of the time period required for the easement to come into being. Waiting fifteen years with no safeguards that the solar access will not be terminated or substantially diminished, would hardly insure protection for existing active and passive solar energy systems. The homeowner utilizing solar energy is at the mercy of his neighbor and needs immediate protection. However, the doctrine may still retain some vitality to protect a solar energy user's long-term interest in access to sunlight.

#### Nuisance Actions as Preserving Solar Access

At common law, liability in nuisance required proof of both wrongful conduct and substantial harm.<sup>25</sup> Both of these requirements raise obstacles to recovery in solar access actions. The prevailing view in nuisance cases is that there can be no recovery where the offensive structure serves a useful and beneficial purpose, and this is true where injurious intent and a fair degree of harm have been shown.<sup>26</sup> Only where a property owner has cut off a neighbor's sunlight for no justifiable reason has the right to light been protected.<sup>27</sup> Additionally, the court must determine that a loss of light constitutes a substantial harm to the plaintiff. Nevertheless, since nuisance litigation characteristically involves a balancing of interests; the balance being struck between utility and harm, giving due consideration to the character of the locality, social pressures, and the



opportunities of all to avoid or reduce the injuries<sup>28</sup> - such process could lead to the recognition of the right of solar access.

Where two incompatible land uses generate a nuisance claim, the balancing of the equities in the case tends to reflect the changing priorities of society. In light of the potential of solar energy to ease the energy crisis in the United States, it is conceivable that, in the future, a court might tip the balance in favor of solar energy, despite the currently prevailing reluctance of the courts to recognize the right to sunlight in the absence of express covenants or easements.

### Conclusion

It is imperative that the user of solar energy secure legal rights to his source of fuel. Two cases illustrate the harsh consequences of not securing such rights. In Ash v. Tate,<sup>29</sup> 73 F.2d the court decided against the user of light, air and view. In this case, the parties' homes were a mere eighteen inches apart. The plaintiff's home contained a window which permitted a view across the porch of the defendant. The plaintiff was a semi-invalid and enjoyed sitting hours at a time at the window to enjoy the view from it. The defendant subsequently installed slotted screens on his porch, which, when closed, obstructed the plaintiff's light, air and view through the window. The court held that in the absence of a statute or covenant which provided the plaintiff with rights of light and air, the plaintiff could not prohibit the defendant from erecting his screens. In a 1959 case, Fontainebleau Hotel Corp. v. Forty-Five Twenty-Five, Inc.,<sup>30</sup> there were two luxury hotels facing the Atlantic Ocean in Florida. The Fontainebleau began construction of a fourteen story addition near its lot line. When completed, the other hotel's cabana, swimming pool and sunbathing areas would be completely shaded after 2 pm during the winter season. The court held that unless the plaintiff could produce a covenant or point the court to a statute protecting its right to solar access, it had no right to the sunlight or airflow across its neighbor's property.

The recent passage of legislation in Connecticut is but a small step toward encouraging the use of solar energy. Unless zoning and subdivision regulations adopted by local planning and zoning commissions assure access to sunlight the ultimate and only assured protection for continued legal right of access to sunlight is for the property owner to enter into a written, legally enforceable document assuring him continued access to his energy source. Although the cost of entering into such an agreement may be prohibitive in some instances,<sup>31</sup> where there is a new subdivision, the developer can easily protect each future home owner by express easements in the deeds conveying each lot. In developed neighborhoods, mutual grants would need to be painstakingly arranged.



Numerous commentators have suggested the development of new legal formulas to solve land use conflicts more efficiently and the abandonment of outdated common law principals which tend to stifle the growth of solar energy.<sup>32</sup> Connecticut's legislation concerning passive solar design for subdivisions is a step in the right direction of encouraging the use of solar energy and providing for the protection of continued solar access to solar collectors. However, until strong local zoning and subdivision ordinances are developed that assure access to sunlight, property owners must continue to rely on common law concepts.



Table 1: Fossil Fuel Requirements For Heating Dwelling Units  
At Various Orientations To True South (In Million BTUs)

Dwelling Type	Annual Space Heating Load (MBTU)	True South	30° Off True South	45° Off True South	60° Off True South	90° Off True South
Conventional	57.7	<b>49.83</b>	51.01	52.27	53.78	57.05
Suntempered	71.4	50.54	53.81	57.77	62.28	77.57
Passive Solar	40.4	17.52	19.40	21.54	25.32	35.18

Source: Based on heat load and solar gain calculations performed by Joel Gordes for the Central Naugatuck Valley Regional Planning Agency, July 21, 1981.



Table 2: Distribution of Projected New Dwelling Units Constructed between 1981 and 1990 by Orientation, Southern Glass, and Passive Solar Design Features In the Central Naugatuck Valley Region

	Total Projected New Units In Place 1981 - 1990	<u>Conventional Dwelling Units</u>				<u>Suntempered Dwelling Units</u>			<u>Passive Solar Dwelling Units</u>	
		True South	Off 30° Degrees	Off 45° Degrees	Off 90° Degrees	True South	Off 30° Degrees	Off 45° Degrees	True South	Off 30° Degrees
No Change Scenario (A)	11,700	2,808	2,808	2,808	2,808	234	0	0	234	0
Increased South Glass Scenario (B)	11,700	2,340	1,170	585	585	2,340	2,340	1,170	1,170	0
Southern Orientation Scenario (C)	11,700	3,510	1,755	1,170	585	2,340	0	0	2,340	0
Passive Solar Scenario (D)	11,700	1,755	585	0	0	2,340	0	0	4,680	2,340

Source: CNVRPA staff work based on housing units projections derived from the Housing Element prepared by the CNVRPA July 23, 1981.



Table 3: Total Energy Requirements of all New Dwellings Constructed in the Central Naugatuck Valley Region Between 1981 and 1990 for Three Different Passive Solar Development Scenarios

Total Energy Requirements in Million BTUs

	<u>Conventional House Types</u>				<u>Suntempered House Types</u>			<u>Passive Solar House Type</u>			
	-----House Orientation Degrees off of True South Azimuth -----										
	0°	30°	45°	90°	0°	30°	45°	0°	30°	Total BTUs	Total Equivalent Gallons of Oil
No Change Scenario (A)	139,923	143,236	146,774	160,196	11,826	0	0	4,100	0	606,055	3,030,275
Increased South Glass Scenario (B)	116,602	59,682	30,578	33,374	118,264	125,915	67,591	20,498	0	572,504	2,862,520
Southern Orientation Scenario (C)	174,903	89,523	61,156	33,374	0	0	0	40,997	0	399,953	1,997,965
Passive Solar Scenario (D)	87,452	29,151	0	0	118,264	0	0	81,994	45,396	362,257	1,811,285

Source: CNVRPA staff work based on housing units projections derived from the Housing Element prepared by the CNVRPA July 23, 1981.



Table 4: Gallons of Fuel Oil Saved Per Year by Implementation of Three Different Passive Solar Development Scenarios Instead of the No Change Scenario in the Central Naugatuck Valley Region: 1990

	Increased South Glass Scenario Savings	Southern Orientation Scenario Savings	Passive Solar Scenario Savings
No Change	3,030,275	3,030,275	3,030,275
Alternative	2,862,520	1,997,865	1,811,285
Gallons of Fuel Oil Saved	167,755	1,032,310	1,218,990

Source: CNVRPA staffbook based on work prepared by Joel Gordes, July 23, 1981.



Table 5

Fuel Mix for Space Heating of Dwelling Units  
Constructed Between 1981 and 1990 Compared to 1979  
Fuel Mix for Space Heating for Existing Dwelling Units

Fuel Type	Fuel Mix for Existing Dwelling Units Percent of Total	Fuel Mix for New Dwelling Units 1981 - 1990 Percent of Total
Fuel Oil	69.5	45%
Natural Gas	20	20%
Electricity	10.5	5%
Wood	0	20%
Coal	0	10%
Total	100%	100%

Source: Exhibit C-43 Connecticut's Energy Outlook 1975 - 1994,  
Connecticut Energy Advisory Board and estimates made by  
the CNVRPA, August 1981.



Table 6: BTU Values of Fuels

1.	Anthracite Coal	25,400,000 BTU/ton
2.	Bituminous Coal (medium volatile)	21,600,000 BTU/ton
3.	Coke	25,380,000 BTU/ton
4.	Residual Oil (No. 2)	138,690 BTU/gallon
5.	Distillate Oil (No. 6)	145,000 BTU/gallon
6.	Natural Gas	1,012 BTU/cubic foot
7.	Electricity	3,413 BTU/kilowatt hour
8.	Medium Heat Value Wood	24,000,000 BTU/cord
9.	Dry Oak	22,750,000 BTU/ton

Source: John Ruckes, Energy Division, Office of Policy and Management, August 21, 1980 (derived from publications issued by the U.S. Department of Energy) and Stone and Webster.



Table 7: Total Equivalent Quantity of Fuel in Specific Units of Measurement  
Required to Supply Projected 1990 Energy Requirements for Space  
Heating of New Dwelling Units Built Between 1981 - 1990 in the CNVR

	Gallons of Oil (Millions)	Cubic Feet of Gas (Millions)	Kilowatts of Electricity (Millions)	Cords of Wood	Tons of Coal
No Change Scenario (A)	2.784	149.716	8.878	10,100	3,975
Increased South Glass Scenario (B)	2.630	141.428	8.387	9,541	3,755
Southern Orientation Scenario (C)	1.837	98.802	5.859	6,665	2,623
Passive Solar Scenario (D)	1.664	89.490	5.307	6,038	2,375



Table 8: EMISSION FACTORS FOR REGULATED POLLUTANTS BY FUEL TYPE

	Distillate Oil #2 lbs/1,000 Gal.	Natural Gas lbs/Million Cubic Feet	Electricity <sup>2</sup> lbs/Kilowatt Hour	Average Type of Wood lbs/Ton	Anthracite Coal lbs/Ton
TSP	2	10.0	.00077	10	90
SO <sub>x</sub>	72 <sup>1</sup>	0.6	.00529 <sup>3</sup>	1.5	76
CO	5	17.0	*	30	1
HC	1	3.0	*	35	0
NO <sub>x</sub>	22	175.0	.00279	10	14

<sup>1</sup>Assumes .5% sulphur content. For other sulphur contents multiply pounds of emission listed above by percent sulphur content to obtain total pounds of emissions.

<sup>2</sup>Assumes 0.5% sulphur content.

<sup>3</sup>Based on a typical efficiency oil burning unit. Emission factors must be discounted by 1.5% to account for transmission losses. It takes .0668 gallons of fuel oil to produce one kilowatt hour.

Source: Connecticut Department of Environmental Protection, June, 1980 and Deming Powell, Northeast Utilities, September 1980.



Table 9: Quantity of Fuel Saved Per Year by Implementation of Three Different Passive Solar Development Scenarios  
Instead of the No Change Scenario in the Central Naugatuck Valley Region: 1990

	Increased South Glass Scenario Savings					Southern Orientation Scenario Savings					Passive Solar Scenario Savings				
	Gallons of Fuel Oil (Millions)	Cubic Feet of Gas (Millions)	Kilowatts of Electricity (Millions)	Cords of Wood	Tons of Coal	Gallons of Fuel Oil (Millions)	Cubic Feet of Gas (Millions)	Kilowatts of Electricity (Millions)	Cords of Wood	Tons of Coal	Gallons of Fuel Oil (Millions)	Cubic Feet of Gas (Millions)	Kilowatts of Electricity (Millions)	Cords of Wood	Tons of Coal
No Change	2.784	149.716	8.878	10,100	3,975	2.784	149.716	8.878	10,100	3,975	2.784	149.716	8.878	10,100	3,975
Alternative	2.630	141.428	8.387	9,541	3,755	1.837	98.802	5.859	6,665	2,623	1.664	89.490	5.307	6,038	2,375
Units of Fuel Saved	.154	8.588	.491	559	220	.947	50.914	3.019	3,435	1,352	1.120	60.226	3.571	4,062	1,600



Table 10: Annual Emission Offsets Generated by Southern Orientations,  
Increased South Glass and Thermal Mass in New Homes in the  
Central Naugatuck Valley Region (in tons)

(Based on 1990 Fuel Mix)

Description of Scenario	TSP	SO <sub>x</sub>	CO	HC	NO <sub>x</sub>
Increased South Glass Scenario (B)					
Emissions from Oil	.15	5.54	.39	.08	1.69
Emissions from Gas	.04	0	.07	.01	.75
Emissions from Electricity	.19	1.29	0	0	.68
Emissions from Wood	2.80	.42	8.39	9.78	2.80
Emissions from Coal	9.90	8.36	.11	0	1.54
Total Emissions	14.08	15.62	8.95	9.87	7.46
Southern Orientation Scenario (C)					
Emissions from Oil	.95	34.09	2.37	.47	10.42
Emissions from Gas	.25	.01	.43	.08	4.46
Emissions from Electricity	1.16	7.98	0	0	4.21
Emissions from Wood	17.18	2.58	51.53	60.11	17.18
Emissions from Coal	60.84	51.38	.68	0	9.46
Total Emissions	80.38	96.04	55.01	60.66	45.73
Passive Solar Scenario (D)					
Emissions from Oil	1.12	40.32	2.80	.56	12.32
Emissions from Gas	.30	.02	.51	.09	5.27
Emissions from Electricity	1.38	9.45	0	0	4.98
Emissions from Wood	20.31	3.05	60.93	71.09	20.31
Emissions from Coal	72.00	60.80	.80	0	11.2
Total Emissions	95.11	113.64	65.04	71.74	54.08



Table 11: Annual Emission Offsets Generated by Southern Orientations,  
Increased South Glass and Thermal Mass in New Homes in the  
Central Naugatuck Valley Region (in tons)

Assumes Fuel Oil is the Only Energy Source for Space Heating

Description of Scenario	TSP	SO <sub>x</sub>	CO	HC	NO <sub>x</sub>
Increased South Glass Scenario (B)	0.17	12.06	.42	.08	1.84
Southern Orientation Scenario (C)	1.03	74.32	2.58	.52	11.36
Passive Solar Scenario (D)	1.22	87.76	3.05	.61	13.41
10% Retrofit Scenario (E)	0.21	14.40	0.50	.10	2.20
Maximum Potential Offset (D + E)	1.43	102.16	3.55	.71	15.61

Source: CNVRPA staffbook based on work prepared  
by Joel Gordes, July 23, 1981.



Table 12: Percent of Energy Requirements for Heating Dwelling Units  
Supplied by Solar Energy at Various Orientations to True South

Dwelling Type	Annual Space Heating Load (MBTU)	True South	30' Off True South	45' Off True South	60' Off True South	90' Off True South
Conventional	57.7	13.63	11.60	9.44	6.80	1.13
Suntempered	71.4	29.21	24.63	19.09	12.78	-8.64
Passive Solar	40.4	56.63	51.98	46.68	37.32	12.93

Source: Based on heat load and solar gain calculations performed by Joel Gordes for the Central Naugatuck Valley Regional Planning Agency, July 21, 1981.



Table 13

Annual Energy Savings Over a Randomly  
Oriented Conventional House (Millions of BTUs)

Orientation	Conventional	Suntempered	Passive Solar
True South	3.02	2.31	35.33
30° Off True South	1.84	0	33.45
45° Off True South	.58	0	31.31
60° Off True South	0	0	27.53

Note: These four orientations serve as reference points for evaluating the range of possible energy savings attributable to orientation. Houses oriented at greater than 60 degrees off true south do not realize any energy benefits from the sun because the randomly oriented house was determined to be oriented at 60 degrees off true south. For conventional dwelling units to be an energy or air quality benefit to the town or region they must face within 60 degrees of true south.

Table 14

Quantity of Offsets Required in Transaction to Date  
(Tons/Year)

Pollutant	Average	Range	Number of Cases
SO <sub>2</sub>	1,226	21-3,763	15
NO <sub>x</sub>	714	22-1,300	3
TSP	290	3.5-1,162	39
CO	3,532	91-6,973	2
HC	512	4-3,650	53

Source: Vivian, Wes, and William, Hall, "An Empirical Examination of U.S. Market Trading in Air Pollution Offsets" (DRAFT), University of Michigan, January 1980.

Note: Due to insufficient data, the exhibit excludes information on 500 offset transactions that occurred in California, and incomplete transactions.



Appendix 1

Building Load Calculations for Conventional,  
Suntempered and Passive Solar House Types



# Conventional House

	U	A	UA
Walls	.07	1711	120
Windows (N.E.W.)	.55	200	110
Doors	.5	35	17
Floor	.05	800/2	20
Roof	.05	1280	64
South Glazing	.55	100	55

$$EUA = 386$$

$$UA_{\text{Infiltration}} = (12,000 \text{ Ft}^3) (.018)(1) = 216$$

$$UA_{\text{Total}} = 602$$

$$Q_{55} = (24)(602)(3987) = 57.7 \text{ MBTU}$$

Load for calculation does not include south glazing, thus:

$$\text{Load} = (24)(547)(3987) = 52.3 \text{ MBTU}$$

$$S = C/L = \frac{100 \text{ Ft}^2}{52.3 \text{ MBTU}} = 1.912$$

# Sun Tempered House

	U	A	UA
Walls	.07	1410	98.7
Windows (N.E.W.)	.55	200	110.
Doors	.5	35	17.5
Roof	.05	1280	64.
Floor	.05	800/2	20.
South Glazing	.55	400	220.

$$EUA = 530.2$$

$$UA_{\text{Infiltration}} = (12,000 \text{ Ft}^3)(.018)(1) = 216$$

$$UA_{\text{Total}} = 746.2$$

$$Q_{55} = (24)(746.2)(3987) = 71.4 \text{ MBTU}$$

Load for calculation does not include south glazing, thus:

$$\text{Load} = (24)(526.2)(3987) = 50.35 \text{ MBTU}$$

$$S = C/L = \frac{400 \text{ Ft}}{50.35 \text{ MBTU}} = 7.94$$



# Passive Solar House

	U	A	UA
Walls	.05	1410	70.5
Windows (N.E.W.)			
Day - 1/3	.55	200	36.63
Night - 2/3	.19	200	25.33
Doors	.13	35	4.55
Roof	.0263	1280	33.66
Floor	.05	800/2	20
South Glazing			
Day - 1/3	.55	400	73.26
Night - 2/3	.19	400	50.62

$$EUA = 314.55$$

$$UA_{\text{Infiltration}} = (12,000)(.018)(.5) = 108$$

$$UA_{\text{Total}} = 422.55$$

$$Q_{55} = (24)(422.55)(3987) = 40.4 \text{ MBTU}$$

Load for calculation does not include south glazing, thus:

$$\text{Load} = (24)(298.67)(3987) = 28.6 \text{ MBTU}$$

$$S = C/L = \frac{400 \text{ Ft}^2}{28.6 \text{ MBTU}} = 13.99$$

## Notes

1) Seasonal heat loss is calculated for a 55 degree-day base temperature which will provide a 65 degree inside temperature due to internal heat gains which have been ignored for this reason.

2) The total seasonal heat loss should be used for calculating amount of fuel displaced when multiplied by the yearly % solar but in the actual computer runs the heat loss which is used is only for those surfaces which are non-collecting surfaces thus the south glazing is not included in that heat loss. South glazing heat loss and gain is calculated in the program internally.

3) Radiation figures were obtained from Dr. Peter J. Lunde author of the book Solar Thermal Engineering (1980, John Wiley & Sons) and runs were made based upon methods described in his book.

4) The conventional house has insulation levels as shown with no special provisions for night insulation of glazing and provides for one air change per hour for infiltration levels. Since it only employs 100 Ft<sup>2</sup> of south glazing, it is only a 6% value of the south glazing to the floor area and is below the threshold for the need of additional thermal mass storage.



5) The suntempered house is essentially the same as the conventional house with the exception that it has 400 Ft<sup>2</sup> of south glazing. No provisions have been made to add thermal mass or night cover for glazing which will result in higher temperature fluctuations and less thermal efficiency for the structure. Infiltration is at one air change per hour.

6) The passive solar house has provisions for night glazing insulation on all window surfaces as well as additional thermal storage. It has one-half air change per hour for infiltration purposes.

7) Mass, when used, is at 30 BTU/Ft<sup>2</sup>/F°

8) I would suspect that the output is conservative since the radiation values, especially during the winter months, use ground reflectivity values that are not minimized for snow cover reflecting onto a vertical surface.



## FOOTNOTES

1. A. McGarity, Solar Heating and Cooling: An Economic Assessment, pp. 36 (National Science Foundation, NSF 76-37), 1977.
2. See, For example, Saddler v. Alexander, 56 S.W. 518 (1900); Metzger v. Hochrein, 107 Wis. 267, 83 N.W. 308 (1900).
3. Rideout v. Knox, 148 Mass. 368, 19 N.E. 390 (1889); Webb v. Lambley, 181 Nev. 385, 148 N.W. 2d 835 (1967).
4. Cardozo, "The Paradoxes of Legal Science" in Selected Writings of Benjamin N. Cardozo, pp. 332 (M. Hall ed. reprint 1975),
5. One commentator has suggested that zoning, standing alone, should not be overrated as a solution to the problem of solar access. Zoning may become less important on the local level as regional and state planning increase and as zoning merges with other controls affecting development. Where protection of solar access is desired, zoning should be combined with an updated building code. Takagi, "Designs on Sunshine: Solar Access in the United States and Japan". 10 Conn. Law Rev 123, 134 (1977).
6. Black's Law Dictionary, 436 (rev. 4th ed. 1968).
7. See generally, R. Powell, The Law of Real Property vol. 3, paragraph 670-86 (rev. ed. P. Rohan 1979).
8. 151 Mass. 585, 24 N.E. 858 (1890); see also, Bryan v. Gosse, 155 Cal. 132, 99 P. 499 (1909), where the court held that creation of light and air easements was not limited to an express grant but could be created by covenant.
9. 72 N.Y. 174 (1878).
10. 23 App. D.C. 122 (1904).
11. 59 Hawaii 491, 583 P. 2d 971 (1978).
12. 385 A. 2d 790 (1978).
13. Kyser v. Zoning Board of Appeals of the Town of Westport, 155 Conn. 236, 254, (1967); B.T. Harris Corp v. Arde Bulova, 135 Conn. 356, 54 A. 2d. 542, (1949); Harris v. Please, 135 Conn. 535, 66 A. 2d. 590 (1949); Ford v. Miles, 93 Conn. 222, 105 A. 443, (1919).
14. Black's Law Dictionary, 436 (rev. 4th. ed. 1968).



Footnotes (Cont'd)

15. See, Hagerty v. Lee, 45 N.J. Eq. 1, 15 A 399 (1888); Homewood Realty Corp v. Safe Deposit and Trust Co., 160 Md. 457, 154 A. 58 (1931).
16. Black's Law Dictionary; 600 (rev. 4th. ed. 1968); Implied easements for sunlight were applied by some courts during the development of right of access to sunlight law in the nineteenth century [e.g., Janes v. Jenkins, 34 Md. 1 (1870)], while other courts refused to apply the doctrine [e.g. Mullen v. Stricker, 19 Ohio St. 135 (1869)].
17. See generally, A. Casner & W. Leach, Cases and Text on Property 1120 (2nd. ed. 1969).
18. Morrison v. Marquardt, 24 Iowa 35 (1868); Keats v. Hugo, 115 Mass. 204 (1870). Robinson v. Clapp, 65 Conn. 365, 32 A. 939 (1895); S.A. Lynch Corp. v. Stone, 211 Ga. 516, 87 S.E. 2d 57 (1955).
19. In Robinson v. Clapp, 65 Conn. 365, (1895), the court found that there was no implied easement of light because "the proposed act of the defendant [in building a structure] would be, in view of all the circumstances, an interruption of light to the plaintiff to the extent of that which is convenient only, not to that which is necessary for the reasonable enjoyment of his dwelling. Indeed, that enjoyment is not reasonable which deprives the defendant of any use of his property, in order merely that the plaintiff may, by reason of such deprivation, have a more comfortable, convenient and better use of his own."
- In Bitello v. Lipson, 80 Conn. 497, 501 (1908) the court stated that "Implied grants of easements of light and air not reasonably necessary for the enjoyment of rights expressly granted are not favored in Connecticut. In this case, the plaintiff alleged that the defendant impaired his right to have light and air pass over a driveway. The court held that the bay window, built eleven and a half feet from the ground, projecting two and a half feet over the driveway, does not interfere with what was necessary for the reasonable enjoyment of the passageway".
20. Scott v. Pape, 31 Ch. D. 554, 571 (1886), See generally, B. Anstey and M. Chavasse, The Right to Light (1963); Powell-Smith, "Defeating Acquisition of Right to Light", 118 New L.J. 855 (1968); Wilkinson, "Let There Be More Light", 118 New L.J. 7 (1968); Takagi, "Designs on Sunshine: Solar Access in the United States and Japan", 10 Conn. L.J. Rev. 123 (1977).
21. Note, "Development Rights Transfer in New York City", 82 Yale L.J. 338, 340 (1972).
22. See generally, R. Powell, supra. note 7 at paragraph 413.



23. Bringinghurst v. O'Donnell, 14 Del. Ch. 225, 124 A. 795 (1924).
24. See, for example, Western v. McGehee, 202 F. Supp. 287 (D.Md 1962). An avigation easement may or may not contain provisions dealing with obstructions within the confines of the easement. It does expressly include the right of airflight over the property. An avigation easement is distinguishable from a clearance or flight obstruction easement which provides that certain airspace will remain clear of obstructions, even though it may not be the airspace through which airplanes fly.
25. W. Prosser, The Law of Torts, section 89 (4th ed. 1971).
26. See. Fontainebleau Hotel Corp. v. Forty-Five Twenty-Five, Inc., 114 So. 2d 357, 359-60 (Fla. Dist. Ct. App. 1959).
27. See, eg., Larkin v. Tsavaris, 85 So. 2d 731 (Fla. 1956).
28. American Law of Property, Vol. 6A, section 28, 26 at 76 (A.J. Casner, ed. 1954).
29. 43 F. 2d 518 (D.C. Cir. 1934).
30. 114 So. 2d 357 (Fla. Dist. Ct. App. 1959).
31. Gergacz, J.W. "Solar Energy Law: Easements of Access to Sunlight". 10 New Mexico L. Rev. 121, 135 (1980).
32. Comment, "Securing Solar Energy Rights: Easements, Nuisance, or Zoning?", 3 Colum. J. Envt'l L. 112, 128 (1976).



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